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98-P011

1995 Annual Status Report

A Summary of Aquatic Vegetation Monitoring at Fixed Transects in Pools 4, 8, 13, and 26 and La Grange Pool of the Upper Mississippi River System

September 1998

The Environmental Management Technical Center issues LTRMP Program Reports to provide Long Term Resource Monitoring Program partners with programmatic documentation, procedures manuals, and annual status reports.

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1995 Annual Status Report
A Summary of Aquatic Vegetation Monitoring at Fixed Transects in Pools 4, 8, 13, and 26 and La Grange Pool of the Upper Mississippi River System

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Preface

The Long Term Resource Monitoring Program (LTRMP) was authorized under the Water Resources Development Act of 1986 (Public Law 99-662) as an element of the U.S. Army Corps of Engineers' Environmental Management Program. The LTRMP is being implemented by the Environmental Management Technical Center (EMTC), a U.S. Geological Survey science center, in cooperation with the five Upper Mississippi River System (UMRS) States of Illinois, Iowa, Minnesota, Missouri, and Wisconsin. The U.S. Army Corps of Engineers provides guidance and has overall Program responsibility. The mode of operation and respective roles of the agencies are outlined in a 1988 Memorandum of Agreement.

The UMRS encompasses the commercially navigable reaches of the Upper Mississippi River, as well as the Illinois River and navigable portions of the Kaskaskia, Black, St. Croix, and Minnesota Rivers. Congress has declared the UMRS to be both a nationally significant ecosystem and a nationally significant commercial navigation system. The mission of the LTRMP is to provide decision makers and river managers with information for maintaining the UMRS as a sustainable large river ecosystem given its multiple-use character. The long-term goals of the Program are to understand the system, determine resource trends and effects, develop management alternatives, manage information, and develop useful products.

This report presents the results of aquatic vegetation transect surveys conducted in 1995 by field station personnel under the direction of the EMTC. Selected areas in Pools 4, 8, 13, and 26 of the Upper Mississippi River and La Grange Pool on the Illinois River were surveyed. This report satisfies, for 1995, Task 2.2.4.6, *Evaluate and Summarize Annual Present-day Results* under Goal 2, *Monitor Resource Change* of the Operating Plan (U.S. Fish and Wildlife Service 1993). The purpose of this report is to provide a summary of data regarding the distribution and abundance of submersed aquatic vegetation collected from the field stations for 1995. This report was developed with funding provided by the Long Term Resource Monitoring Program.

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Abstract

Distribution and frequency of aquatic vegetation in the Upper Mississippi River System are monitored as part of the Long Term Resource Monitoring Program. This report summarizes results of sampling aquatic vegetation along fixed transects in Navigation Pools 4, 8, 13, and 26 in the Upper Mississippi River and La Grange Pool of the Illinois River in 1995. Pool 26 includes 12 miles of the Illinois River upstream of its confluence with the Mississippi River; all of the backwaters surveyed in this river reach are on the lower Illinois River. Plants were sampled using a modified rake technique along fixed transects. Data from additional qualitative surveys (or informals) was used to augment species records in each pool. Twenty-three submersed and rooted floating-leaved species were found in 1995. Pools 4 and 8 harbored the most species, including most of the large-leaved pondweeds, and the number of species decreased in the pools to the south. Submersed aquatic vegetation was most widespread in Pools 8 and 13 throughout the growing season (frequency of about 60%) and least in Pools 4 and 26 (≤30%). Sago pondweed (*Potamogeton pectinatus*) was the dominant species found along the length of the river followed by coon's tail (*Ceratophyllum demersum*). Curly pondweed (*P. crispus*), wild celery (*Vallisneria americana*), and American lotus (*Nelumbo lutea*) were generally widespread in the upper three pools, and their presence varied seasonally. The abundance of curly pondweed peaked during the spring, whereas wild celery and American lotus were late-season strategists. Aquatic vegetation was generally rare in contiguous areas of Pool 26 and La Grange Pool, and where vegetation was sampled (mostly isolated backwaters) fewer species were found than in the three northern pools.

Introduction

Aquatic vegetation of the Upper Mississippi River System (UMRS) is monitored and trends in its status are reported as part of the Long Term Resource Monitoring Program (LTRMP; U.S. Fish and Wildlife Service 1993). This monitoring provides baseline information to which future observations can be compared. In combination with water quality, fish, and invertebrate monitoring, the overall mission of the Program is to provide scientifically sound and useful information for effective river management. The purpose of this report is to document vegetation sampling at selected transects in 1995.

Historically, submersed aquatic vegetation (SAV) has played an important role in the UMRS ecosystem. These plant communities provide food for migratory waterfowl (Korschgen et. al. 1988) and improvement of water quality by stabilizing sediments, filtering out suspended materials, and taking up nutrients that can otherwise support nuisance algal growth (Barko et al. 1991). Macrophytes also provide nursery areas for young fish, serve as spawning habitat, and support invertebrate populations by providing structure and surface area (Engel 1990).

We have been unable to understand or anticipate many changes in the distribution of SAV within the UMRS, partly because few studies have adequately addressed the questions. Biologists have high interest and concern for this important resource, however, especially in view of the drastic decline of SAV in the Illinois River in the 1950s, of which only remnant populations survive (Talkington and Semonin 1991). Concern for SAV in the Upper Mississippi River escalated in the mid- to late-1980s when widespread and sudden declines in the abundance of wild celery (*Vallisneria americana*) were observed in Pools 5 to 19 (E.

Nelson and C. Cheap, U.S. Fish and Wildlife Service, Winona, Minnesota, unpublished data; C. Korschgen, Northern Prairie Wildlife Research Center, Jamestown, South Dakota, unpublished data; J. Lyons, U.S. Fish and Wildlife Service, McGregor, Iowa, personal communication; R. Anderson, Western Illinois University, Macomb, personal communication; W. Thrune, U.S. Fish and Wildlife Service, La Crosse, Wisconsin, personal communication).

Long-term monitoring can play a substantial role in increasing an understanding of trends in this resource by addressing the following questions:

(1) How temporally and spatially dynamic is SAV in the UMRS?
(2) Are we observing short-term fluctuations in one or more species or is SAV becoming irreparably lost?
(3) Based on patterns observed, what factors most likely contribute to the changes?

This report documents the results of sampling submersed and rooted floating-leaved vegetation along transects at selected locations in 1995. It provides baseline information to evaluate changing conditions. The 1995 growing season was the fifth year that we conducted field surveys in designated LTRMP study reaches. The objectives for monitoring aquatic vegetation in the UMRS are to

(1) document the distribution of SAV at selected locations of the UMRS,
(2) compare current distribution of SAV with past distribution, and
(3) identify environmental factors which may influence long- and short-term changes in the distribution and abundance of SAV.

Fulfillment of these objectives requires focused research in addition to monitoring.

Study Areas

The LTRMP vegetation study area consists of five reaches within the UMRS, four on the Upper Mississippi River and one on the Illinois River (Figure 1). Study areas are referred to herein by the navigation pool designations according to the U.S. Army Corps of Engineers lock and dam system. The Upper Mississippi River navigation pools studied were Pool 4 (Mississippi River mile [M] 752 to 797), Pool 8 (M 679 to 703), Pool 13 (M 523 to 557), Pool 26 (M 202 to 242), and La Grange Pool of the Illinois River (Illinois River mile [I] 80 to 158). Pool 26 includes 12 miles of the lower Illinois River upstream of its confluence (M 218.0) with the Mississippi River. River miles for the Upper Mississippi River are measured from the confluence of the Mississippi and Ohio Rivers, and for the Illinois River from the confluence of the Mississippi and Illinois Rivers.

These study areas were chosen, in part, to reflect important differences in geomorphology, floodplain land use, and water level management strategies that exist within the UMRS. Pools 4, 8, and 13 are geomorphically complex with contiguous and isolated backwaters and numerous interconnected channels (Table 1). A relatively large proportion of the aquatic area in these pools comprise backwaters and impounded areas. The upper portions retain the most riverine character with braided channels, forested islands, and relatively large water-level fluctuations (Peck and Smart 1986). In contrast, the lower portions of these pools provide a shallow, more lacustrine environment. Pool 26 has a greater proportion of main channel area. La Grange Pool has a high percentage of area in backwaters, but very little SAV has been observed. Consequently, SAV sampling effort is less intensive in the two southern pools.

Figure 1. Location of Navigation Pools 4, 8, 13, and 26 and La Grange Pool in the Upper Mississippi River System where aquatic vegetation was surveyed, Long Term Resource Monitoring Program, 1995. The Open River reach was not selected as a study site because of the lack of habitat for submersed vegetation.

Table 1. Area and relative proportions of aquatic habitats (based on geomorphology) by navigation pool for select reaches of the Upper Mississippi River System studied as part of the Long Term Resource Monitoring Program.[a]

	Main channel		Side channel		Backwater		Lake		Impounded		Isolated		
Location	**Area (ha)**	**%**	**Area (ha)**	**%**	**Area (ha)**	**%**	**Area (ha)**	**%**	**Area (ha)**	**%**	**Area (ha)**	**%**	**Total area (ha)**
Pool 4	1,240	8	721	5	2,300	16	9,764[b]	66	0	0	660	5	14,685
Pool 8	1,256	16	1,380	17	1,767	22	0	0	3,476	43	124	2	8,003
Pool 13	2,700	27	805	8	2,810	28	0	0	3,560	36	116	1	9,991
Pool 26	4,860	57	1,496	18	415	5	948[c]	11	176	2	580	7	8,475
La Grange Pool[d]	2,398	22	143	1	5,676	51	0	0	0	0	2,835	26	11,052

[a] Data for Pools 4, 8, 13, and 26 were based on the sampling strata coverage. Data for La Grange Pool were based on the aquatic areas coverage.
[b] Refers to Lake Pepin, a tributary delta lake.
[c] Refers to Swan Lake.
[d] La Grange Pool is located on the Illinois River.

In Pool 4, we surveyed contiguous backwaters where transects were established in 1991 (Figure 2). We also surveyed Upper Mud Lake, which was added in 1993. The transects were distributed in both the upper and lower portions of the pool, but not in Lake Pepin. Upper pool locations included Dead Slough Lake, Goose Lake, Upper Mud Lake, Mud Lake, and Catherine Pass (referred to as Bay City Flats in previous reports; Appendix A). Lower pool locations (below Lake Pepin) included Robinson Lake, Peterson Lake, Big Lake, and Rice Lake and Big Lake Bay, which are part of the Big Lake area. A Habitat Rehabilitation Project (HREP), which involved dredging part of Big Lake Bay, was completed in spring, 1993.

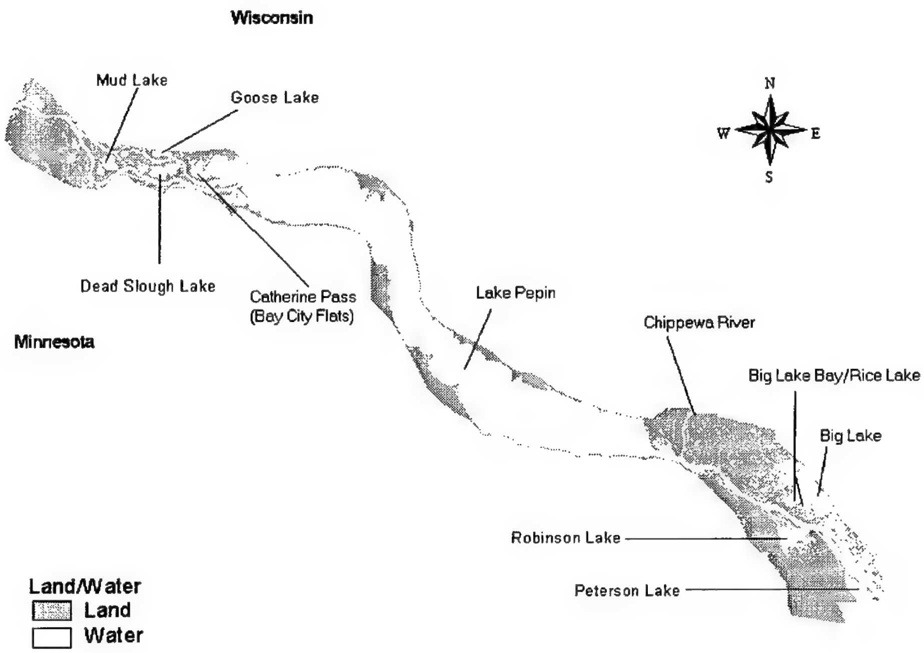

Figure 2. Backwater locations in Pool 4 (Upper Mississippi River) where transects were monitored for aquatic vegetation, Long Term Resource Monitoring Program, 1995.

In Pool 8, we surveyed five backwaters where transects were established in 1991 (Figure 3). Locations included Target Lake, Lawrence Lake, a backwater area near Goose Island, Shady Maple, and the interior of Horseshoe Island (Appendix A). We added a backwater near Stoddard, Wisconsin, in 1992, and two backwaters, Blue Lake and the interior of Boomerang Island, in 1993. Horseshoe Island and Boomerang Island are part of the Pool 8 Islands HREP. Most backwaters were in the lower two-thirds of the pool.

In Pool 13, we surveyed seven backwaters where transects were established in 1991 (Figure 4). Most of the backwaters were in the middle and lower portions of the pool and included Brown's Lake, Savanna Bay, Spring Lake, Pomme de Terre, Potter's Marsh, Johnson Creek, and Johnson Creek Levee (Appendix A). Brown's Lake and Potter's Marsh are part of HREPs initiated in 1988 and 1994, respectively.

In Pool 26, we surveyed three backwaters where transects were established in 1991 (Figure 5). These backwaters included the Calhoun Point area—consisting of several backwater lakes, sloughs, and ephemeral ponds—and Swan and Stump Lakes (Appendix A). We also surveyed Fuller Lake, added in 1992. The reach known as Pool 26 includes portions of both the Mississippi and lower Illinois Rivers. All backwater locations sampled for vegetation were in the lower 12 miles of the Illinois River. Most transects were in isolated backwaters that are intensively managed as moist soil units (to mimic preimpoundment conditions). Swan

Lake is a large shallow area contiguous with the Illinois River and, although it is not managed as a moist soil unit, low water levels in the summer often limit access.

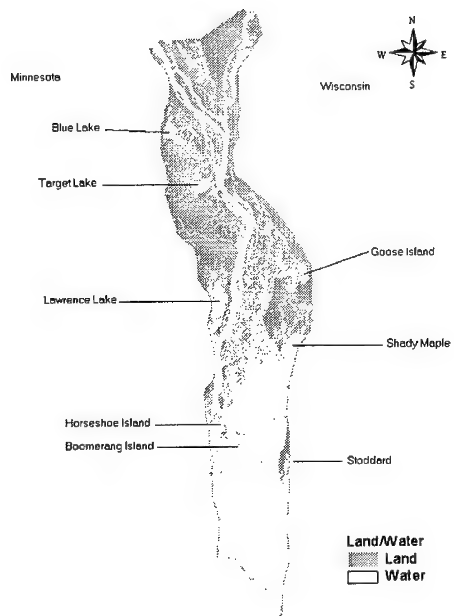

Figure 3. Backwater locations in Pool 8 (Upper Mississippi River) where transects were monitored for aquatic vegetation, Long Term Resource Monitoring Program, 1995.

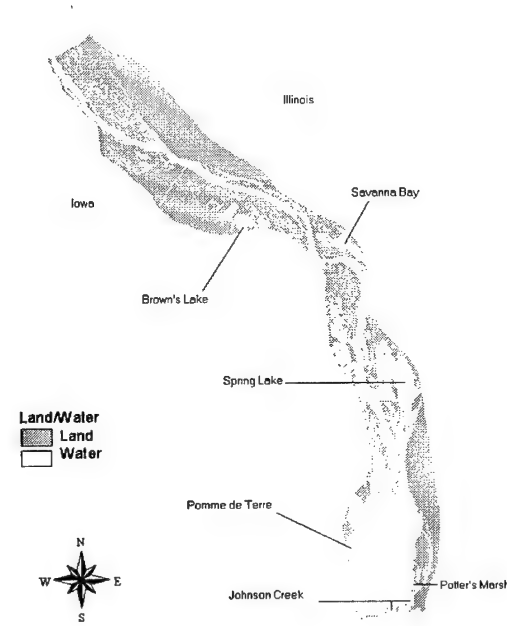

Figure 4. Backwater locations in Pool 13 (Upper Mississippi River) where transects were monitored for aquatic vegetation, Long Term Resource Monitoring Program, 1995.

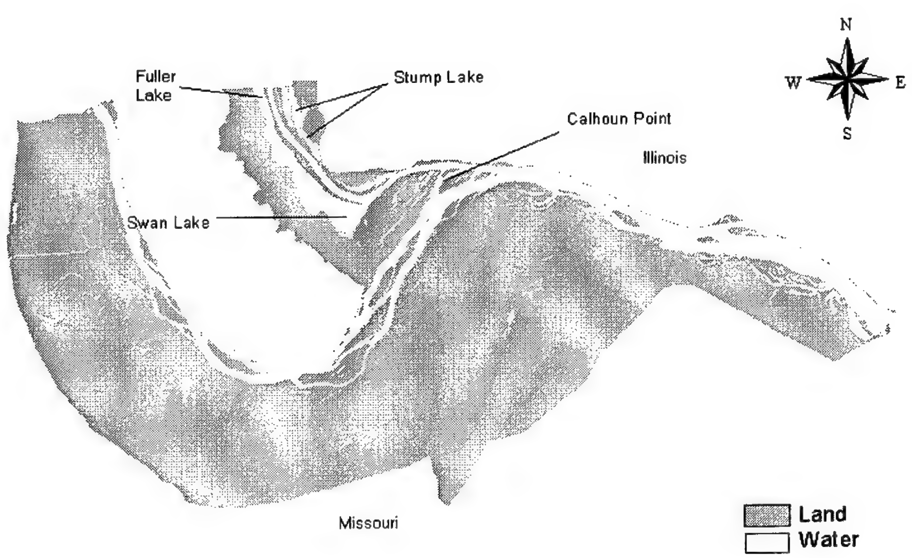

Figure 5. Backwater locations in Pool 26 (Upper Mississippi River) where transects were monitored for aquatic vegetation, Long Term Resource Monitoring Program, 1995.

In La Grange Pool, we have surveyed three backwaters since 1991 and the Grape Island area since 1992 (Figure 6; Appendix A). Bulrush Pond in Banner Marsh State Fish and Wildlife Area, Point Lake, and Spring Lake are separated from the main stem of the Illinois River by levees. Water levels in the main river influence the Grape Island area and Point Lake, but not Spring Lake and Banner Marsh, which are behind larger drainage-district levees.

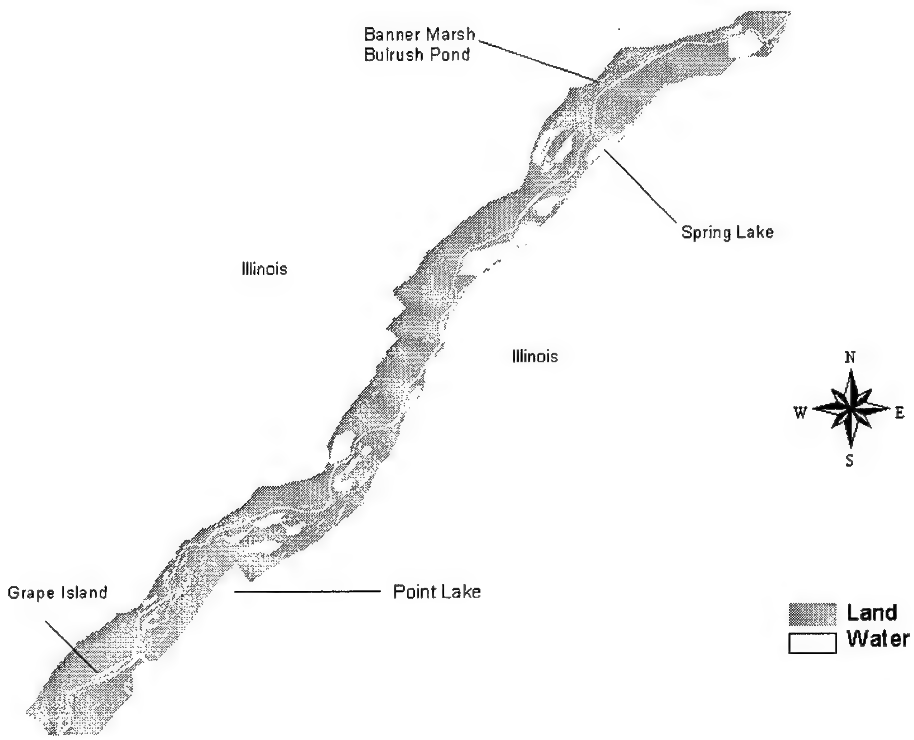

Figure 6. Backwater locations in La Grange Pool (Illinois River) where transects were monitored for aquatic vegetation, Long Term Resource Monitoring Program, 1995.

Methods

Transect Sampling

Transects were positioned perpendicular to shorelines at regular intervals, from 50 to 200 m apart depending on the size of the area. Transects typically traversed an entire backwater. Sampling was performed twice in most locations during the growing season to observe seasonal changes. Spring sampling began on May 15 and ended June 15. The summer sampling period ran from July 19 to September 12 (Appendix A). In spring of 1995, sampling was discontinued in Spring Lake (La Grange Pool); however, substantial changes in SAV were observed and sampling was resumed late in the year to document these changes.

Sampling along the transects was conducted at regularly spaced intervals or sites. Sites were surveyed every 15 m in Pools 8, 13, and 26 and La Grange Pool, but every 30 m in Pool 4 because of the large size of some backwaters. The sampling method was modified from a technique used by Jessen and Lound (1962). At each site along a transect, a sampling area about 2 m in diameter was divided into thirds. Plants on the bottom were sampled once within each third by lowering a long-handled thatching rake and twisting it to

snag samples. The thatching rake had a 38 cm (15-inch) head with 20, 12.7-cm-long (5-inch) teeth and sampled an area of approximately 0.1 m^2. The submersed species on the rake were identified and recorded. After all three twists were made, each species retrieved was assigned a rating of from 1 to 4, based on the number of times it appeared on the rake. A rating of 4 was assigned only if a species completely covered the rake teeth on all three twists.

If rooted floating-leaved species were present, they were assigned a rating of 1 to 4 based on the amount of vegetative cover visible in the entire 2-m sampling area (1 = 1–25% cover, 2 = 26–50% cover, 3 = 51–75% cover, and 4 = 76–100% cover). Rooted floating-leaved species were not included in analysis of relative frequency. Nonrooted floating species (e.g., Lemnaceae) were recorded if they exceeded 5% of the surface area, but were excluded from analysis.

Fassett (1957), Voss (1972, 1985) and Gleason and Cronquist (1991) were the primary keys used for plant identification. Scientific nomenclature and common names are based on those found in the U.S. Department of Agriculture PLANTS Database on the Internet (http://plants.usda.gov/plants/). Leafy pondweed (*Potamogeton foliosus*) and small pondweed (*P. pusillus*) were collectively referred to as "small and leafy pondweeds." They were not distinguished from each other during field sampling and were combined for analysis. Chara (*Chara* spp.), a macroalga, was analyzed together with the vascular plants.

An example of each species found during monitoring was saved as a voucher specimen. Voucher specimens were pressed, dried, mounted, labeled, and stored at each field station. Rare species and unusual specimens were saved for reference and sent to outside experts for verification. A list of submersed and floating-leaved species found during LTRMP monitoring since 1991 appears in Appendix B.

Informal Surveys

To gain perspective on the distribution and composition of SAV in habitats other than transect locations, we qualitatively surveyed many portions within each study pool. When vegetation was observed, we recorded species composition, relative abundance, approximate bed size, water depth, substrate type, and location information. Informal surveys have not been conducted in Pool 26 since 1992 when extensive surveys revealed that SAV was generally scarce.

Environmental Factors

Water depth was recorded at each site. The maximum rooting depth was calculated by averaging the deepest 10% of sites with SAV. Depths were not adjusted for water surface elevations, which fluctuate because of water level management and natural events. A qualitative sediment assessment based on visual and tactile characteristics was recorded for each transect, but was excluded from analysis.

Daily water surface elevations were measured by the U.S. Army Corps of Engineers (Figure 7). Most backwaters with transects were in the middle to lower sections of the pools, therefore, select mid-pool gage readings were used to produce stage hydrographs for Pool 4 (Wabasha, Minnesota; M760.4), Pool 8 (La Crosse, Wisconsin; M696.8), Pool 26 (Grafton, Illinois; M218.0), and La Grange Pool (Beardstown, Illinois; I88.0). Because Pool 13 had no mid-pool gage recorded for 1995, comparative data for that pool were not available. Mid-pool gages are preferred because most transects are located in that part of the pool and data from other locations, such as tailwaters, have more extreme fluctuations and are less accurate. Similar stage

hydrograph patterns are observed along the length of a pool and depend ultimately on discharge, which determines the method of pool level control.

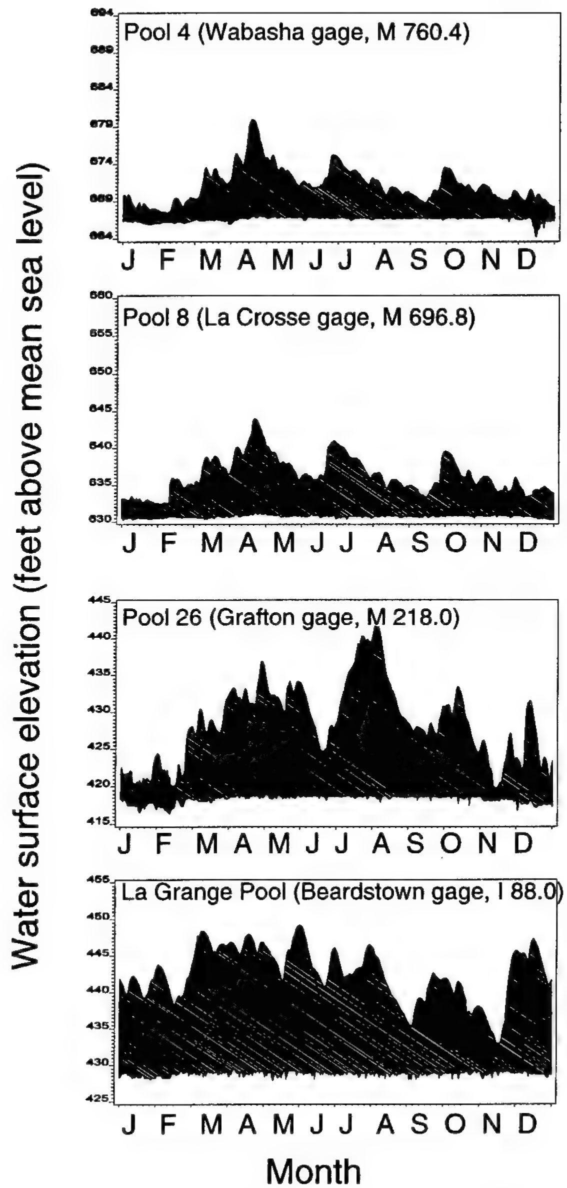

Figure 7. Daily water surface elevations (WSE) for select mid-pool gages within selected navigation pools of the Upper Mississippi River System. Solid line shows 1995 stage hydrograph. Dotted line indicates mean annual stage hydrograph and shaded area shows minimum and maximum WSEs for the period of record from 1950–1995. (Mississippi River mile [M]; Illinois River mile [I]; USACE data). Mid-pool gage data are not available for Pool 13.

Statistical Analysis

The frequency of a species is defined as

$$f_i = j_i/n$$

where

j_i = number of sample sites containing species *i* on at least one of the three rake twists,
n = total number of sample sites.

Relative frequency of a species is defined as

$$rf_i = e_i/Ef$$

where

e_i = number of rake twists in which species *i* was present,
Ef = sum of the total number of times present for each species.

Frequency and relative frequency are expressed as percent. Records of rooted floating-leaved vegetation were omitted from the relative frequency calculations.

Chi-square tests were used to test for significant seasonal differences in the number of vegetated sites in each pool. To test for significant change in a species frequency between sampling periods, a value for Z was calculated for each species in each backwater location using the following formula:

$$Z = p_1 - p_2 / \sqrt{pq[(1/n_1)+(1/n_2)]}$$

where

$p = (j_1 + j_2)/(n_1 + n_2)$;
$q = 1-p$;
$p_1 = j_1/n_1$;
$p_2 = j_2/n_2$;
n_1 and n_2 = number of sampling sites, spring and summer, respectively;
j_1 and j_2 = number of times species *j* was found during the spring and summer sampling periods, respectively.

Results and Discussion

All Pools

We found 20 species of submersed plants and 3 of rooted floating-leaved plants in 1995 (Table 2). Of these, 16 submersed species were found along transects, and the remainder during informal surveys. The number of species found declined as we moved in a southerly direction. Pool 4 was the most species rich (22 species, 19 of which were submersed) and Pool 26 the most depauperate (8 species, 7 of which were submersed). La Grange Pool of the Illinois River hosted 10 species, a relatively low number. As Peck and Smart (1986) noted, most species were found above Pool 14.

Table 2. Frequency (%) of aquatic plant species found in Pools 4, 8, 13, and 26 of the Upper Mississippi River and La Grange Pool (LG) of the Illinois River, 1995.

	Spring					Summer				
Species	**4**	**8**	**13**	**26**	**LG**	**4**	**8**	**13**	**26**	**LG**
Submersed species										
bladderwort, common (*Utricularia macrorhiza*)	IS[a]	0.4	–[b]	–	–	–	1.6	–	–	–
buttercup, longbeak (*Ranunculus longirostris*)	IS	–	–	–	–	–	–	–	–	–
chara (*Chara* spp.)	IS	–	–	–	–	–	–	<0.1	–	+[c]
coon's tail (*Ceratophyllum demersum*)	1.5	34.5	12.3	–	25.7	4.0	47.8	21.9	2.1	44.6
pondweed, alpine (*Potamogeton alpinus*)	IS	–	–	–	–	–	–	–	–	–
pondweed, curly (*P. crispus*)	10.9	15.0	10.0	0.2	14.3	1.0	5.0	4.7	–	–
pondweed, flatstem (*P. zosteriformis*)	0.1	0.7	0.5	–	–	–	0.6	2.0	–	–
pondweed, horned (*Zannichellia palustris*)	0.2	0.1	–	–	IS	0.1	–	0.1	–	–
pondweed, longleaf (*P. nodosus*)	–	0.4	2.8	0.9	2.9	0.5	1.1	4.6	4.2	13.8
pondweed, ribbonleaf (*P. epihydrus*)	IS	–	–	–	–	–	–	–	–	–
pondweed, Richardson's (*P. richardsonii*)	IS	–	–	–	–	–	–	–	–	–
pondweed, sago (*P. pectinatus*)	19.9	19.8	52.2	22.5	7.1	5.0	25.4	44.3	11.0	9.2
pondweeds, small and leafy (*P. pusillus, P. foliosus*)	–	11.0	0.1	–	2.9	0.5	9.8	–	4.2	9.2
water stargrass (*Heteranthera dubia*)	–	–	12.5	–	–	0.6	0.5	19.3	2.1	–
watermilfoil, Eurasian (*Myriophyllum spicatum*)	1.6	13.2	8.1	–	14.3	2.2	11.6	7.4	–	16.9
watermilfoil, shortspike (*M. sibiricum*)	0.1	IS	–	–	–	–	–	–	–	–
waternymph, nodding (*Najas flexilis*)	–	–	0.7	–	–	0.4	4.8	2.8	–	–
waternymph, southern (*N. guadalupensis*)	–	–	–	–	–	–	–	2.1	6.3	–
waterweed, Canadian (*Elodea canadensis*)	0.4	4.2	6.5	–	–	1.3	5.2	7.7	–	+
wild celery (*Vallisneria americana*)	–	–	5.1	–	–	8.8	0.1	13.2	–	–
Number of submersed species (transects)	**8**	**10**	**11**	**3**	**6**	**11**	**12**	**13**	**6**	**7**
Rooted floating-leaved species										
American lotus (*Nelumbo lutea*)	0.1	0.2	7.4	–	–	2.8	11.4	31.1	11.9	+

Table 2. Continued.

Species	Spring					Summer				
	4	8	13	26	LG	4	8	13	26	LG
pondlily, yellow (*Nuphar lutea*)	–	3.1	–	–	–	0.1	3.8	–	–	–
waterlily, American white (*Nymphaea odorata*)	7.7	23.2	IS	–	–	9.1	35.6	–	–	–
Number of rooted floating-leaved species (transects)	**2**	**3**	**1**	**0**	**0**	**3**	**3**	**1**	**1**	**1**
Total number of species per pool[d]	**22**	**17**	**16**	**8**	**10**					

[a] IS indicates that a species was recorded during informal surveys but not during transect sampling.
[b] The symbol "–" indicates the species was not found.
[c] The symbol "+" indicates a species was found in an area that was sampled only once during the field season.
[d] Includes data from spring and summer transects as well as informal surveys.

Sago pondweed (*Potamogeton pectinatus*), coon's tail (*Ceratophyllum demersum*), and curly pondweed (*P. crispus*) were the most cosmopolitan species, present in all pools and in the greatest proportion of sites (Table 2). Longleaf pondweed (*P. nodosus*), small and leafy pondweeds, and American lotus (*Nelumbo lutea*) were also widely distributed. Eurasian watermilfoil (*Myriophyllum spicatum*) was found in all the study sites except Pool 26. Less common species were also less widely distributed. common bladderwort (*Utricularia macrorhiza*), longbeak buttercup (*Ranunculus longirostris*), short spike watermilfoil (*M. sibiricum*), and yellow pondlily (*Nuphar lutea*) were found in one or both of the two northern pools (Pools 4 and 8). Southern waternymph (*Najas guadalupensis*) was found only in the southern reach (Pools 13 and 26). The range of nodding waternymph (*N. flexilis*) was wider and, like American white waterlily (*Nymphaea odorata*), spanned Pools 4, 8, and 13. In general, curly pondweed growth peaked in the spring and subsequently declined. Other species, such as southern and nodding waternymph, water stargrass (*Heteranthera dubia*), wild celery, and American lotus increased in frequency later in the season.

In most pools (4, 8, 26, and La Grange), the percent of sites with SAV changed significantly between sampling periods, but the direction of change varied among pools (Table 3). Whether vegetation increased or declined could usually be attributed to the regional phenology of the most dominant species. For example, in Pools 4 and 26, the general drop in the percent of submersed vegetated sites reflected a summer decline in sago pondweed. Conversely, in Pool 8 and La Grange Pool, sago pondweed and coon's tail expanded during the summer, thereby increasing the percent of submersed vegetated sites.

Table 3. Frequency of vegetated sites of submersed species along transects in Pools 4, 8, 13, and 26 of the Upper Mississippi River and La Grange Pool of the Illinois River during spring and summer sampling, 1995.

Pool	Spring (%)	*n*	Summer (%)	*n*	Significance[a]
4	30.0	1,073	18.1	1,014	*[b] $P < 0.001$
8	57.1	1,291	62.2	1,250	* $P < 0.009$
13	61.5	1,018	63.4	1,111	$P < 0.382$
26	23.8	426	10.7	429	* $P < 0.001$
La Grange[c]	34.3	70	47.7	65	* $P < 0.113$

[a] Probability value is based on Chi-square test where $\propto = 0.05$
[b] The symbol "*" indicates significant change.
[c] Spring Lake was excluded from calculations.

The maximum rooting depth of SAV decreased from north to south in the upper three study pools (Pools 4, 8, and 13; Table 4). In general, SAV was recorded at greater depths in the spring than in the summer. This trend reflects the effects of seasonal precipitation which typically swells water surface elevations (WSE) in the springtime (Figure 7). Also, mid-summer WSEs were higher than the annual mean in the northern three pools.

Table 4. Maximum rooting depths (m) of submersed aquatic vegetation in Pools 4, 8, 13, and 26 of the Upper Mississippi River and La Grange Pool of the Illinois River during spring and summer transect sampling, 1995.[a]

Pool	Spring	*n*	Summer	*n*
4	1.9 ± 0.03	32	1.4 ± 0.05	19
8	1.7 ± 0.01	74	1.3 ± 0.01	78
13	1.6 ± 0.01	63	1.0 ± 0.01	70
26[b]	4.1 ± 0.00	10	0.5 ± 0.02	5
La Grange[b, c]	2.7 ± 0.09	3	2.5 ± 0.12	3

[a] Maximum rooting depth was calculated by averaging the deepest 10% of sites with SAV.
[b] Water levels exceeded flood stage during spring (Figure 7).
[c] Spring Lake was excluded from calculations.

In the lower two pools (Pool 26 and La Grange Pool), spring flooding in the Illinois River resulted in record WSEs. Subsequently, maximum rooting depths in the spring were inflated. The deepest (4.1 m, spring) and most shallow (0.5 m, summer) maximum rooting depths were observed in Pool 26 illustrating the extreme conditions to which SAV is exposed. Intensive water-level control in backwaters managed as moist soil units makes it difficult to compare Pool 26 with the other LTRMP study reaches. The maximum rooting depth of SAV in the La Grange Pool was also high but more consistent, a result of spring flooding and later an artifact of a water level management strategy aimed at improving fish production in isolated areas.

Pool 4

Of the 13 submersed species found along transects in Pool 4, 8 were recorded in the spring and 11 in the summer (Table 5). Most species found were rare, present in fewer than 2% of the sites. Flatstem pondweed (*P. zosteriformis*) and short spike watermilfoil were found only during spring sampling. Small and leafy pondweeds, longleaf pondweed, water stargrass, nodding waternymph, and wild celery were sampled only during the summer.

During spring sampling, curly and sago pondweeds were the most widespread; however, they were present in 20% or fewer of the sites surveyed (Table 5). These two species collectively contributed to more than 90% of the relative frequencies during the spring effort. During summer sampling, no species exceeded a frequency of 10%. Wild celery displaced sago pondweed as the dominant species (relative frequency of 44%) and curly pondweed virtually disappeared. Coon's tail, sago pondweed, and Eurasian watermilfoil together made up almost 42% of the remaining SAV community, even though they were each found in 5% or fewer of the sites.

Table 5. Frequencies and relative frequencies of submersed aquatic plant species found along transects in Pool 4 of the Upper Mississippi River during spring (May 22–June 13) and summer (July 26–August 24) sampling periods, 1995.

	Frequencies (%)		Relative frequencies (%)	
Species	**Spring** *n* = **1073**	**Summer** *n* = **1014**	**Spring**	**Summer**
coon's tail (*Ceratophyllum demersum*)	1.5	4.0	3.1	14.1
pondweed, curly (*Potamogeton crispus*)	10.9	1.0	31.5	3.3
pondweed, flatstem (*P. zosteriformis*)	0.1	0	0.2	0
pondweed, horned (*Zannichellia palustris*)	0.2	0.1	0.3	0.5
pondweed, longleaf (*P. nodosus*)	0	0.5	0	1.7
pondweed, sago (*P. pectinatus*)	19.9	5.0	60.5	18.5
pondweeds, small and leafy (*P. pusillus, P. foliosus*)	0	0.5	0	1.4
water stargrass (*Heteranthera dubia*)	0	0.6	0	1.7
watermilfoil, Eurasian (*Myriophyllum spicatum*)	1.6	2.2	3.6	8.8
watermilfoil, short spike (*M. sibiricum*)	0.1	0	0.2	0
waternymph, nodding (*Najas flexilis*)	0	0.4	0	1.7
waterweed, Canadian (*Elodea canadensis*)	0.4	1.3	0.6	4.1
wild celery (*Vallisneria americana*)	0	8.8	0	44.2
Percent of vegetated sites[a]	**30**	**18.1**		

[a] From Table 3.

In 1995, more species were found in Pool 4 than in the other study sites and grew in water up to 1.9 m deep (Tables 2 and 4); however, the overall presence of vegetation was low (30% and 18%, spring and summer respectively; Table 5). Upstream of Lake Pepin, SAV was sparse and composed almost singularly of sago pondweed; whereas, many more species were found in backwaters downstream of Lake Pepin (Table 6). Lake Pepin is a 22-mile long tributary delta lake in the middle of Pool 4 that was created by vast amounts of sand deposited at the confluence of the Chippewa River.

Seasonal differences were observed for particular species and locations—upper versus lower Pool 4 (Table 6). Sago and curly pondweeds matured and died in some locations between sampling periods. Sago pondweed declined in all upper pool backwaters, but remained almost unchanged in the lower pool. Wild celery, coon's tail, and Canadian waterweed (*Elodea canadensis*) increased in a number of lower pool locations between spring and summer sampling. No significant changes were observed in any backwaters for flatstem, small and leafy, and longleaf pondweeds, horned pondweed (*Zannichellia palustris*), water stargrass, Eurasian and short spike watermilfoil, and nodding waternymph. This may, in part, be because of their low frequency. Submersed aquatic vegetation was most dynamic in Robinson Lake, where two species declined and three species expanded between sampling periods.

Table 6. Seasonality of submersed aquatic plant species sampled along transects in backwaters of Pool 4 of the Upper Mississippi River, 1995.

Species	Decreased between spring and summer sampling periods[a]	No change between spring and summer sampling periods	Increased between spring and summer sampling periods[a]
coon's tail (*Ceratophyllum demersum*)		Big Lake Big Lake Bay Lower Peterson Lake Peterson Lake Rice Lake Upper Mud Lake[b]	Robinson Lake
pondweed, curly (*Potamogeton crispus*)	Big Lake Bay Robinson Lake	Big Lake Lower Peterson Lake Rice Lake Peterson Lake	
pondweed, flatstem (*P. zosteriformis*)		Big Lake	
pondweed, horned (*Zannichellia palustris*)		Big Lake Bay Peterson Lake	
pondweed, longleaf (*P. nodosus*)		Big Lake Rice Lake Robinson Lake	
pondweed, sago (*P. pectinatus*)	Catherine Pass[b] Dead Slough Lake[b] Goose Lake[b] Mud Lake[b] Robinson Lake Upper Mud Lake[b]	Big Lake Big Lake Bay Lower Peterson Lake Peterson Lake Rice Lake	
pondweeds, small and leafy (*P. pusillus, P. foliosus*)		Peterson Lake Rice Lake Robinson Lake	
water stargrass (*Heteranthera dubia*)		Big Lake Lower Peterson Lake Peterson Lake Robinson Lake	
watermilfoil, Eurasian (*Myriophyllum spicatum*)		Big Lake Bay Big Lake Lower Peterson Lake Rice Lake Robinson Lake	

Table 6. Continued.

Species	Decreased between spring and summer sampling periods[a]	No change between spring and summer sampling periods	Increased between spring and summer sampling periods[a]
watermilfoil, short spike (*M. sibiricum*)		Robinson Lake	
waternymph, nodding (*Najas flexilis*)		Peterson Lake Robinson Lake	
waterweed, Canadian (*Elodea canadensis*)		Big Lake Rice Lake	Robinson Lake
wild celery (*Vallisneria americana*)		Rice Lake	Big Lake Lower Peterson Lake Peterson Lake Robinson Lake

[a] Changes in a species frequency were significant at $P < 0.05$.
[b] Upper Pool 4 locations.

Pool 8

Of the 13 submersed species found along transects in Pool 8, ten were recorded in the spring and twelve were found in the summer (Table 7). Horned pondweed was found only during spring sampling, whereas water stargrass, nodding waternymph, and wild celery were recorded only during summer.

Table 7. Frequencies and relative frequencies of submersed aquatic plant species found along transects in Pool 8 of the Upper Mississippi River during spring (May 15–June 7) and summer (July 20–August 23) sampling periods, 1995.

Species	Frequencies (%)		Relative frequencies (%)	
	Spring $n = 1291$	Summer $n = 1250$	Spring	Summer
bladderwort, common (*Utricularia macrorhiza*)	0.4	1.6	0.2	1.0
coon's tail (*Ceratophyllum demersum*)	34.5	47.8	38.7	51.6
pondweed, curly (*Potamogeton crispus*)	15.0	5.0	12.9	3.4
pondweed, flatstem (*P. zosteriformis*)	0.7	0.6	0.6	0.4
pondweed, horned (*Zannichellia palustris*)	0.1	0	<0.1	0
pondweed, longleaf (*P. nodosus*)	0.4	1.1	0.4	0.8
pondweed, sago (*P. pectinatus*)	19.8	25.4	17.9	18.4
pondweeds, small and leafy (*P. pusillus, P. foliosus*)	11.0	9.8	11.0	7.3
water stargrass (*Heteranthera dubia*)	0	0.5	0	0.3
watermilfoil, Eurasian (*Myriophyllum spicatum*)	13.2	11.6	13.8	8.3

Table 7. Continued.

Species	Frequencies (%) Spring $n = 1291$	Frequencies (%) Summer $n = 1250$	Relative frequencies (%) Spring	Relative frequencies (%) Summer
waternymph, nodding (*Najas flexilis*)	0	4.8	0	4.0
waterweed, Canadian (*Elodea canadensis*)	4.2	5.2	4.5	4.5
wild celery (*Vallisneria americana*)	0	0.1	0	<0.1
Percent of vegetated sites[a]	**57.1**	**62.2**		

[a] From Table 3.

Coon's tail was the most frequently recorded submersed species during spring (35%) and summer (48%) sampling periods. Coon's tail and sago pondweed dominated the submersed community in both sampling periods combining for greater than 55% of the relative frequencies. Water stargrass and wild celery were rarely found in Pool 8 transect locations (<1%). The percent of submersed vegetated sites increased from 57% (spring) to 62% (summer).

Seasonal differences were recorded in seven of eight backwaters surveyed in Pool 8 in 1995 (Table 8). Sago pondweed and curly pondweed were widespread, present in all eight backwater locations. Coon's tail, sago pondweed, and nodding waternymph increased in at least three backwaters. Conversely, curly pondweed declined in four of the eight locations. No seasonal differences were recorded for flatstem, longleaf, and horned pondweeds, water stargrass, Canadian waterweed, and wild celery. Blue Lake was the most dynamic location, where two species declined and four species increased.

Table 8. Seasonality of submersed aquatic plant species sampled along transects in backwaters of Pool 8 of the Upper Mississippi River, 1995.

Species	Decreased between spring and summer sampling period[a]	No change between spring and summer sampling period	Increased between spring and summer sampling periods[a]
bladderwort, common (*Utricularia macrorhiza*)		Lawrence Lake Target Lake	Blue Lake
coon's tail (*Ceratophyllum demersum*)		Horseshoe Island Shady Maple Stoddard, Wisconsin	Blue Lake Goose Island Lawrence Lake Target Lake
pondweed, curly (*Potamogeton crispus*)	Blue Lake Boomerang Island Lawrence Lake Stoddard, Wisconsin	Goose Island Horseshoe Island Shady Maple Target Lake	
pondweed, flatstem (*P. zosteriformis*)		Goose Island Horseshoe Island Lawrence Lake	
pondweed, horned (*Zannichellia palustris*)		Horseshoe Island	

Table 8. Continued.

Species	Decreased between spring and summer sampling period[a]	No change between spring and summer sampling period	Increased between spring and summer sampling periods[a]
pondweed, longleaf (*P. nodosus*)		Goose Island Lawrence Lake Shady Maple Target Lake	
pondweed, sago (*P. pectinatus*)	Boomerang Island	Goose Island Horseshoe Island Lawrence Lake Stoddard, Wisconsin	Blue Lake Shady Maple Target Lake
pondweeds, small and leafy (*P. pusillus, P. foliosus*)	Blue Lake	Goose Island Lawrence Lake Shady Maple Stoddard, Wisconsin Target Lake	
water stargrass (*Heteranthera dubia*)		Boomerang Island Goose Island Lawrence Lake Shady Maple Target Lake	
watermilfoil, Eurasian (*Myriophyllum spicatum*)	Lawrence Lake	Boomerang Island Horseshoe Island Shady Maple Target Lake	Goose Island
waternymph, nodding (*Najas flexilis*)		Goose Island Horseshoe Island	Blue Lake Lawrence Lake Target Lake
waterweed, Canadian (*Elodea canadensis*)		Blue Lake Goose Island Lawrence Lake Stoddard, Wisconsin Target Lake	
wild celery (*Vallisneria americana*)		Lawrence Lake	

[a] Changes in a species frequency were significant at $P < 0.05$.

Pool 13

Of the 14 submersed species found along transects in Pool 13 in 1995, 11 were found during the spring sampling period and 13 in the summer (Table 9). Small and leafy pondweeds were found only during the spring sampling, whereas chara (*Chara* spp.), horned pondweed, and southern waternymph were found only during the summer sampling.

Table 9. Frequencies and relative frequencies of submersed aquatic plant species found along transects in Pool 13 of the Upper Mississippi River during spring (May 19–June 15) and summer (July 19–August 17) sampling periods, 1995.

Species	Frequencies (%)		Relative frequencies (%)	
	Spring $n = 1,018$	Summer $n = 1,111$	Spring	Summer
chara (*Chara* spp.)	0	<0.1	0	0.1
coon's tail (*Ceratophyllum demersum*)	12.3	21.9	10.8	16.2
pondweed, curly (*Potamogeton crispus*)	10.0	4.7	6.1	2.2
pondweed, flatstem (*P. zosteriformis*)	0.5	2.0	0.2	1.1
pondweed, horned (*Zannichellia palustris*)	0	0.1	0	0.1
pondweed, longleaf (*P. nodosus*)	2.8	4.6	1.7	3.1
pondweed, sago (*P. pectinatus*)	52.2	44.3	51.4	34.8
pondweeds, small and leafy (*P. pusillus, P. foliosus*)	0.1	0	<0.1	0
water stargrass (*Heteranthera dubia*)	12.5	19.3	9.9	15.0
watermilfoil, Eurasian (*Myriophyllum spicatum*)	8.1	7.4	9.3	6.7
waternymph, nodding (*Najas flexilis*)	0.7	2.8	0.5	2.3
waternymph, southern (*N. guadalupensis*)	0	2.1	0	1.5
waterweed, Canadian (*Elodea canadensis*)	6.5	7.7	6.2	7.1
wild celery (*Vallisneria americana*)	5.1	13.2	3.9	9.8
Percent of vegetated sites[a]	**61.5**	**63.4**		

[a] From Table 3.

More than 60% of the sites surveyed were vegetated throughout the growing season (Table 9). Sago pondweed was the most abundant species found during both sampling periods (52% and 44% in the spring and summer, respectively) followed by coon's tail and water stargrass. Coon's tail and water stargrass became more widespread as the growing season advanced, so that by summer their combined relative frequency (31%) neared that of sago pondweed (35%). Wild celery frequency increased between sampling periods (from 5% to 13%), becoming the fourth most important species in Pool 13 by the summer (relative frequency of 10%).

Seasonal differences were observed in most species in at least some of the backwaters surveyed (Table 10). Curly and sago pondweeds showed localized declines. However, the latter also increased in other backwaters. Coon's tail, water stargrass, wild celery, flatstem and longleaf pondweeds, and nodding and southern waternymph increased in at least one location. The only species whose frequencies did not change significantly in any of the locations were Eurasian watermilfoil and Canadian waterweed. Most late season growth was observed in Pomme de Terre, Johnson Creek, and Spring Lake, where three species increased in each location.

Table 10. Seasonality of submersed aquatic plant species sampled along transects in backwaters of Pool 13 of the Upper Mississippi River, 1995.

Species	Decreased between spring and summer sampling period[a]	No change between spring and summer sampling period	Increased between spring and summer sampling period[a]
chara (*Chara* spp.)		Johnson Creek	
coon's tail (*Ceratophyllum demersum*)		Johnson Creek Johnson Creek Levee Pomme de Terre Potter's Marsh	Brown's Lake Savanna Bay Spring Lake
pondweed, curly (*Potamogeton crispus*)	Johnson Creek Spring Lake	Brown's Lake Johnson Creek Levee Pomme de Terre Potter's Marsh Savanna Bay	
pondweed, flatstem (*P. zosteriformis*)		Brown's Lake Johnson Creek Levee Savanna Bay Spring Lake	Johnson Creek
pondweed, horned (*Zannichellia palustris*)		Savanna Bay	
pondweed, longleaf (*P. nodosus*)		Brown's Lake Johnson Creek Johnson Creek Levee Pomme de Terre Savanna Bay	Spring Lake
pondweed, sago (*P. pectinatus*)	Johnson Creek Levee Potter's Marsh Spring Lake	Johnson Creek Savanna Bay	Brown's Lake Pomme de Terre
pondweeds, small and leafy (*P. pusillus, P. foliosus*)		Johnson Creek	
water stargrass (*Heteranthera dubia*)		Johnson Creek Savanna Bay Spring Lake	Johnson Creek Levee Pomme de Terre Potter's Marsh
watermilfoil, Eurasian (*Myriophyllum spicatum*)		Johnson Creek Johnson Creek Levee Pomme de Terre Potter's Marsh Spring Lake	
waternymph, nodding (*Najas flexilis*)		Brown's Lake Johnson Creek Johnson Creek Levee Pomme de Terre Savanna Bay	Spring Lake
waternymph, southern (*N. guadalupensis*)		Johnson Creek Levee Potter's Marsh Spring Lake	Johnson Creek

Table 10. Continued.

Species	Decreased between spring and summer sampling period[a]	No change between spring and summer sampling period	Increased between spring and summer sampling period[a]
waterweed, Canadian (*Elodea canadensis*)		Johnson Creek Johnson Creek Levee Pomme de Terre Savannah Bay Spring Lake	
wild celery (*Vallisneria americana*)		Johnson Creek Levee Potter's Marsh Savanna Bay Spring Lake	Johnson Creek Pomme de Terre

[a] Changes in a species frequency were significant at $P < 0.05$.

Pool 26

Of the seven submersed species found along transects in Pool 26 in 1995, three were found during the spring sampling and six were surveyed in the summer (Table 11). Curly pondweed was found only in the spring, whereas coon's tail, small and leafy pondweeds, water stargrass, and southern waternymph were found only during summer sampling. The frequency of submersed vegetated sites in Pool 26 was halved despite the appearance of additional species.

Table 11. Frequencies and relative frequencies of submersed aquatic plant species found along transects in Pool 26 of the Upper Mississippi River during spring (June 7–13) and summer (August 16–22) sampling periods, 1995.

	Frequencies (%)		Relative frequencies (%)	
Species	Spring $n = 426$	Summer $n = 429$	Spring	Summer
coon's tail (*Ceratophyllum demersum*)	0	2.1	0	4.4
pondweed, curly (*Potamogeton crispus*)	0.2	0	1.0	0
pondweed, longleaf (*P. nodosus*)	0.9	4.2	4.0	9.2
pondweed, sago (*P. pectinatus*)	22.5	11.0	95.0	38.6
pondweeds, small and leafy (*P. pusillus, P. foliosus*)	0	4.2	0	13.0
water stargrass (*Heteranthera dubia*)	0	2.1	0	7.3
waternymph, southern (*Najas guadalupensis*)	0	6.3	0	27.5
Percent of vegetated sites	**23.8**	**10.7**		

Sago pondweed dominated the plant community and was the only species whose frequency exceeded 10% during the entire season (Table 11). Sago pondweed declined between sampling periods in Swan Lake where it was the only species found (Table 12). In Stump Lake, vegetation changed seasonally. By summer, the presence of small and leafy pondweeds, longleaf pondweed, and southern waternymph expanded. In the

southern portion of Stump Lake, American lotus was observed as the dominant species by summer and was seen covering much of the water surface.

Table 12. Seasonality of submersed aquatic plant species sampled along transects in backwaters of Pool 26 of the Upper Mississippi River, 1995.

Species	Decreased between spring and summer sampling periods[a]	No change between spring and summer sampling periods	Increased between spring and summer sampling periods[a]
coon's tail (*Ceratophyllum demersum*)		Stump Lake	
pondweed, curly (*Potamogeton crispus*)		Calhoun Point	
pondweed, longleaf (*P. nodosus*)			Stump Lake
pondweed, sago (*P. pectinatus*)	Swan Lake	Stump Lake	
pondweeds, small and leafy (*P. pusillus, P. foliosus*)			Stump Lake
water stargrass (*Heteranthera dubia*)		Stump Lake	
waternymph, southern (*Najas guadalupensis*)			Stump Lake

[a] Changes in a species frequency were significant at $P < 0.05$.

Overall, the percent of submersed vegetated sites was very low (Table 11). Calhoun Point had a single sample of curly pondweed and Fuller Lake was devoid of SAV. The lack of vegetation in this river reach was probably influenced by spring flooding, shown by water levels that exceeded flood stage and rooting depths that exceeded 4 m (Figure 7; Table 4).

La Grange Pool

Of the eight submersed species found along transects in the La Grange Pool in 1995, six were found during the spring sampling and five were sampled in the summer (Table 13). In Spring Lake, surveyed only late in the season, six species were found including the only 1995 records for chara and Canadian waterweed. In the spring, coon's tail was the most widespread plant (26%) followed by curly pondweed (14%) and Eurasian watermilfoil (14%), and together they accounted for almost 90% of the relative frequencies. Eurasian watermilfoil and curly pondweed were present at the same number of sites; however, the former was encountered more frequently at each site, accounting for its higher relative frequency values. During the summer sampling, the presence of coon's tail expanded to 45% and continued to dominate the plant community. Eurasian watermilfoil remained the second most common species, but curly pondweed disappeared. Longleaf pondweed expanded over the growing season reaching a relative frequency of 15%.

Table 13. Frequencies and relative frequencies of submersed aquatic plant species found along transects in La Grange Pool of the Illinois River during spring (May 22–June 14) and summer (August 8–September 12) sampling periods, 1995.[a]

Species	Frequencies (%)			Relative frequencies (%)		
	Spring $n = 70$	Summer $n = 65$	Spring Lake[a] $n = 146$	Spring	Summer	Spring Lake[a]
chara (*Chara* spp.)	–[b]	–	6.8	–	–	13.4
coon's tail (*Ceratophyllum demersum*)	25.7	44.6	11.6	46.9	50.7	17.4
pondweed, curly (*Potamogeton crispus*)	14.3	0	0.7	12.5	0	0.6
pondweed, longleaf (*P. nodosus*)	2.9	13.8	–	3.1	15.0	–
pondweed, sago (*P. pectinatus*)	7.1	9.2	0.7	5.2	7.8	0.6
pondweeds, small and leafy (*P. pusillus, P. foliosus*)	2.9	9.2	–	3.1	8.6	–
watermilfoil, Eurasian (*Myriophyllum spicatum*)	14.3	16.9	31.5	29.2	17.9	61.6
waterweed, Canadian (*Elodea canadensis*)	–	–	4.8	–	–	6.4
Percent of vegetated sites[c]	**34.3**	**47.7**	**43.8**			

[a] Spring Lake sites were monitored during summer only and were calculated separately.
[b] The symbol "–" indicates the species was not found.
[c] From Table 3.

Few seasonal differences were observed in 1995 (Table 14). Only curly and longleaf pondweeds declined and expanded, respectively, in Banner Marsh. The only contiguous area where transects were located, Grape Island, was devoid of plants. Vegetation in the Grape Island area and Point Lake were probably impacted by spring flooding (Figure 7).

Table 14. Seasonality of submersed aquatic plant species sampled along transects in backwaters of La Grange Pool of the Illinois River, 1995.

Species	Decreased between spring and summer sampling periods[a]	No change between spring and summer sampling periods	Increased between spring and summer sampling periods[a]
coon's tail (*Ceratophyllum demersum*)		Banner Marsh Point Lake	
pondweed, curly (*Potamogeton crispus*)	Banner Marsh		
pondweed, longleaf (*P. nodosus*)			Banner Marsh
pondweed, sago (*P. pectinatus*)		Banner Marsh	
pondweeds, small and leafy (*P. pusillus, P. foliosus*)		Banner Marsh	
watermilfoil, Eurasian (*Myriophyllum spicatum*)		Banner Marsh	

[a] Changes in a species frequency were significant at $P < 0.05$.

Spring Lake could not be compared to other locations because it was surveyed only once in 1995. Following the 1994 growing season we decided to cease transect sampling in Spring Lake, but important changes occurred. As in previous years, Eurasian watermilfoil grew profusely in the spring creating a large homogenous bed with low diversity in the plant community. In the middle of the growing season, Eurasian watermilfoil suddenly died back and transect sampling was reinstated. Subsequently, five additional species were found (Table 13). Inspection of Eurasian watermilfoil tissue later revealed that the milfoil weevil (*Euhrychiopsis lecontei*) was present in Spring Lake during the 1995 growing season (Wayne Henderson, Fisheries Biologist, Illinois Department of Natural Resources, personal communication).

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References

Barko, J. W., D. Gunnison, and S. R. Carpenter. 1991. Sediment interactions with submersed macrophyte growth and community dynamics. Aquatic Botany 41:41–65.

Engel, S. 1990. Ecosystem responses to growth and control of submerged macrophytes: A literature review. Technical Bulletin 170. Wisconsin Department of Natural Resources, Madison. 22 pp.

Fassett, N.C. 1957. A manual of aquatic plants. University of Wisconsin Press, Madison. 405 pp.

Gleason, H.A., and A. Cronquist. 1991. A manual of vascular plants of northeastern United States and adjacent Canada. 2nd edition. The New York Botanical Garden, Bronx. 910 pp.

Jessen, R., and R. Lound. 1962. An evaluation of survey techniques for submerged aquatic plants. Game Investigational Report 6. Minnesota Department of Conservation, St. Paul. 10 pp.

Korschgen, C. E., L. S. George, and W. L. Green. 1988. Feeding ecology of canvasbacks staging on Pool 7 of the Upper Mississippi River. Pages 237–249 *in* M. W. Weller, editor. Waterfowl in winter. University of Minnesota Press, Minneapolis.

Peck, J. H., and M. M. Smart. 1986. An assessment of the aquatic and wetland vegetation of the Upper Mississippi River. Hydrobiologia 136:57–76.

Talkington, L. M., and R. G. Semonin. 1991. The Illinois River: working for our state. Miscellaneous Publication 128. Illinois State Water Survey, Champaign. 51 pp.

U.S. Fish and Wildlife Service. 1993. Operating Plan for the Upper Mississippi River System Long Term Resource Monitoring Program. Environmental Management Technical Center, Onalaska, Wisconsin, Revised September 1993. EMTC 91-P002R. 179 pp. (NTIS #PB94-160199)

Voss, E. G. 1972. Michigan Flora, Part I, Gymnosperms and Monocots. Cranbrook Institute of Science, Bloomfield Hills, Michigan. 488 pp.

Voss, E. G. 1985. Michigan Flora, Part II, Dicots. Regents of the University of Michigan, Ann Arbor. 724 pp.

Appendix A

Locations, Number of Transects and Sites, Sampling Dates, and Distances Between Sites Surveyed in Pools 4, 8, 13, and 26 of the Upper Mississippi River and La Grange Pool of the Illinois River During the 1995 Sampling Season

Location	Number of transects spring:summer	Number of sites spring	Number of sites summer	Sampling dates spring	Sampling dates summer	Distance between sites (m)
Pool 4						
Upper Mud Lake (M791.5)[a]	4:4	36	41	6/13	8/24	30
Mud Lake (M791.3)	3:3	61	68	6/12	8/18	30
Dead Slough Lake (M789.2, M788.5, M788.0)	9:9	162	135	6/7–8	8/15–16	30
Goose Lake (M788.G)[b]	3:3	31	28	6/8–9	8/15	30
Catherine Pass (Bay City Flats; M787.0)[c]	3:3	85	80	6/9	8/16–17	30
Robinson Lake (M758.R)[b]	9:9	230	227	5/25–26, 30–31	8/1–4, 7	30
Big Lake Bay (M758.5)	3:3	54	43	5/31; 6/5	8/8	30
Rice Lake (M758.0)	3:3	36	34	5/31	8/7, 14	30
Big Lake (M757.5)	5:5	171	158	6/5–6	8/9–11, 14	30
Peterson Lake (M754.8, M754.5)	6:6	77	72	5/22–23	7/26–27	30
Lower Peterson Lake (M753.5)	4:4	130	128	5/23–25	7/28, 31	30
Total Pool 4	**52:52**	**1073**	**1014**	**15**	**20**	
Pool 8						
Blue Lake (M697.0)	3:3	124	118	5/31	8/14, 16	15
Target Lake (M696.0)	11:11	291	298	5/15, 17, 22	7/20, 25, 26–28	15
Goose Island (M692.0)	5:5	118	113	5/23	8/8	15

Location	Number of transects spring:summer	Number of sites spring	Number of sites summer	Sampling dates spring	Sampling dates summer	Distance between sites (m)
Lawrence Lake (M691.0)	10:10	422	386	5/30; 6/1, 5–7	8/17–18, 21–23	15
Shady Maple (M690.0)	3:3	102	104	5/26	8/9	15
Horseshoe Island (Pool 8 Islands HREP; M687.0)[d]	5:5	82	80	5/25	8/4	15
Boomerang Island (Pool 8 Islands HREP; M686.0)[d]	4:4	104	104	5/24	8/1	15
Stoddard, Wisconsin (M684.0)	4:4	48	47	5/16	8/3	15
Total Pool 8	**45:45**	**1291**	**1250**	**14**	**17**	
Pool 13						
Brown's Lake (M545.1, M544.5)	20:20	367	458	6/5–7, 12	8/2–4, 8–9, 11	15
Savanna Bay (M541.5, M540.5, M539.5)	12:12	137	138	5/26, 30	7/26–27	15
Spring Lake (M534.8, M533.6, M532.0)	12:12	175	173	5/31, 6/1	7/28, 31; 8/1	15
Pomme de Terre (M526.0)	5:5	75	71	5/19	7/19	15
Potter's Marsh (M524.0)	6:6	87	94	6/15	8/17	15
Johnson Creek Levee (M523.5)	4:4	117	107	6/13–14	8/14–16	15
Johnson Creek (M523.0)	2:2	60	70	5/22, 25	7/20–21	15
Total Pool 13	**61:61**	**1018**	**1111**	**14**	**18**	
Pool 26						
Calhoun Point (I003.0)[e]	11:9	82	86	6/7	8/16, 18	15
Swan Lake (I005.5)	5:5	149	159	6/7	8/17	15
Stump Lake (I010.0)	8:8	166	155	6/13	8/22	15

Location	Number of transects spring:summer	Number of sites spring	Number of sites summer	Sampling dates spring	Sampling dates summer	Distance between sites (m)
Fuller Lake (I011.5)	2:2	29	29	6/13	8/18	15
Total Pool 26	**26:24**	**426**	**429**	**2**	**5**	
La Grange Pool						
Grape Island (I086.4)	3:3	21	15	6/13	8/10	15
Point Lake (I100.0)	6:6	25	26	6/14	8/8–9	15
Spring Lake (I135.5)	0:5	not sampled	146	not sampled	9/8, 11–12	15
Banner Marsh (Bulrush Pond; I140.0)[c]	2:2	24	24	5/22–23	8/8	15
Total La Grange Pool	**11:16**	**70**	**211**	**4**	**7**	

[a] Mississippi River miles, measured from the confluence of the Mississippi and Ohio Rivers.
[b] "G" and "R" to distinguish this lake from another lake with the same river mile.
[c] Locally recognized alternate name.
[d] Part of the Pool 8 Islands, Habitat Rehabilitation and Enhancement Project.
[e] Pool 26 is located at the confluence of the Illinois and Mississippi Rivers and the portions named here extend up the Illinois River, are managed by the Illinois Department of Natural Resources, and are designated by Illinois River miles. Illinois River miles are measured form the confluence of the Illinois and Mississippi Rivers.

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Appendix B

List of Submersed and Floating-leaved Aquatic Species Present atTransect Sites in Pools 4, 8, 13, and 26 of the Upper Mississippi River and La Grange Pool of the Illinois River During Monitoring for the Long Term Resource Monitoring Program, 1991–1995[a]

Family	Scientific name	Common name
Azollaceae (Salviniaceae)	*Azolla* spp.[b]	watervelvet, mosquitofern
Ceratophyllaceae	*Ceratophyllum demersum* L.	coon's tail, coontail
Characeae	*Chara* spp.	chara
Characeae	*Nitella* spp.	nitella
Haloragaceae	*Myriophyllum sibiricum* Komarov	northern watermilfoil, shortspike watermilfoil
Haloragaceae	*Myriophyllum spicatum* L.	Eurasian watermilfoil, spike watermilfoil
Hydrocharitaceae	*Elodea canadensis* Michx.	Canadian waterweed
Hydrocharitaceae	*Vallisneria americana* Michx.	wild celery, American eelgrass
Lemnaceae	*Lemna minor* L.[b]	lesser duckweed, small duckweed, common duckweed
Lemnaceae	*Lemna trisulca* L.[b]	star duckweed
Lemnaceae	*Spirodela polyrhiza* (L.) Schleid.[b]	greater duckweed, big duckweed, common duckweed
Lemnaceae	*Wolffia braziliensis* Weddell[b, c]	Brazillian watermeal
Lemnaceae	*Wolffia columbiana* Karst.[b]	Columbian watermeal
Lentibulariaceae	*Utricularia macrorhiza* Le Conte (*Utricularia vulgaris* L.)	common bladderwort
Najadaceae	*Najas flexilis* (Willd.) Rostk. & Schmidt	bushy pondweed, slender naiad, nodding waternymph
Najadaceae	*Najas gracillima* (A. Braun ex Engelm.) Magnus	slender waternymph
Najadaceae	*Najas guadalupensis* (Spreng.) Magnus[d]	southern waternymph
Nymphaeaceae	*Nelumbo lutea* Willd.	American lotus
Nymphaeaceae	*Nuphar lutea* (L.) Sm	yellow pondlily
Nymphaeaceae	*Nymphaea odorata* Ait.	American white waterlily
Onagraceae	*Ludwigia decurrens* Walt.[b]	wingleaf primrosewillow
Pontederiaceae	*Heteranthera dubia* (Jacq.) MacM. (*Zosterella dubia* [Jacq.] Small)	water stargrass, grassleaf mudplantain
Potamogetonaceae	*Potamogeton alpinus* Balbis[c]	alpine pondweed, red pondweed
Potamogetonaceae	*Potamogeton crispus* L.	curly pondweed, curlyleaf pondweed

Family	Scientific name	Common name
Potamogetonaceae	*Potamogeton epihydrus* Raf.	ribbonleaf pondweed
Potamogetonaceae	*Potamogeton foliosus* Raf.	leafy pondweed
Potamogetonaceae	*Potamogeton illinoisensis* Morong.[e]	Illinois pondweed
Potamogetonaceae	*Potamogeton nodosus* Poir	river pondweed, American pondweed, longleaf pondweed
Potamogetonaceae	*Potamogeton pectinatus* L	sago pondweed
Potamogetonaceae	*Potamogeton pusillus* L.	small pondweed, slender pondweed
Potamogetonaceae	*Potamogeton richardsonii* (Benn.) Rydb.	Richardson's pondweed
Potamogetonaceae	*Potamogeton zosteriformis* Fern.	flatstem pondweed
Ranunculaceae	*Ranunculus flabellaris* Raf.	yellow water buttercup
Ranunculaceae	*Ranunculus longirostris* Godr.[f]	longbeak buttercup, white watercrowfoot
Zannichelliaceae	*Zannichellia palustris* L.	horned pondweed

[a] Scientific nomenclature and common names follow the U.S. Department of Agriculture PLANTS Database on the Internet (http://plants.usda.gov/plants/). Common names most often used by Upper Mississippi River managers are also included.
[b] Species excluded from analysis.
[c] Gleason and Cronquist (1991) treat this as two separate species: *Wolffia papulifera* C. Thompson and *Wolffia punctata* Griseb.
[d] Verified for Pool 13 by Dr. E. Cawley, Loras College, Iowa.
[e] Verified by Dr. C.B. Hellquist, North Adams State College, Massachusetts.
[f] *Ranunculus longirostris* and *R. trichophyllus* were combined (Voss 1985).

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13. ABSTRACT (Maximum 200 words)

Distribution and frequency of aquatic vegetation in the Upper Mississippi River System are monitored as part of the Long Term Resource Monitoring Program. This report summarizes results of sampling aquatic vegetation along fixed transects in Navigation Pools 4, 8, 13, and 26 in the Upper Mississippi River and La Grange Pool of the Illinois River in 1995. Pool 26 includes 12 miles of the Illinois River upstream of its confluence with the Mississippi River; all of the backwaters surveyed in this river reach are on the lower Illinois River. Plants were sampled using a modified rake technique along fixed transects. Data from additional qualitative surveys (or informals) was used to augment species records in each pool. Twenty-three submersed and rooted floating-leaved species were found in 1995. Pools 4 and 8 harbored the most species, including most of the large-leaved pondweeds, and the number of species decreased in the pools to the south. Submersed aquatic vegetation was most widespread in Pools 8 and 13 throughout the growing season (frequency of about 60%) and least in Pools 4 and 26 (≤30%). Sago pondweed (*Potamogeton pectinatus*) was the dominant species found along the length of the river followed by coon's tail (*Ceratophyllum demersum*). Curly pondweed (*P. crispus*), wild celery (*Vallisneria americana*), and American lotus (*Nelumbo lutea*) were generally widespread in the upper three pools, and their presence varied seasonally. The abundance of curly pondweed peaked during the spring, whereas wild celery and American lotus were later season strategists. Aquatic vegetation was generally rare in contiguous areas of Pool 26 and La Grange Pool, and where vegetation was sampled (mostly isolated backwaters) fewer species were found than in the three northern pools.

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